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Request for examination according to § 44, Patent Act, is submitted.

(54) Bio-filter for biological cleaning of exhaust air

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Description

The invention concerns a biofilter for biological cleaning of exhaust air. The filter is made up of layers of organic material within which substances contained in gases introduced to the filter are degraded by the metabolic activity of microorganisms.

It is known that organic substances such as coir, fibrous peat from heather, pine chips, and the like can be superimposed in layers and that exhaust air from rooms can be passed through them. These layers are about 1 to 1.5 m deep.

Open surface filters are used in many places because of their economy. In this type of filter, the biologically active filter layer in which the sorption and microbial degradation of the substances in the exhaust air consists of a filling or organic filter materials about 1 to 1.5 meters deep. A previously humidified flow of raw gas enters the filter layer from the bottom. The filter is open at the top.

One problem that often occurs with this type of filter structure is maintenance of the steady moisture content of the filling, which is essential for the metabolic activity of the microorganisms. There is a danger of drying, especially for the surfaces of the filter layer exposed to atmospheric effects. Drying can result in formation of cracks in the filling material and to breakthrough of the gas. The degradative ability of the microorganisms is very severely damaged in the dried zones, so that dry regions can in some circumstances drastically reduce the cleaning power of a biofilter.

In such a biofilter, the substances in the exhaust air are degraded through the metabolic activity of microorganisms and thus eliminated from the air. That requires that all the substances in the gases which must be eliminated be biodegradable. It is desirable, then, that dust and greases first be separately filtered out of the exhaust air so that they do not contaminate the biofilter. The advantage of the biofilter is that the filter material loaded with pollutants is continuously regenerated by the activity of the microorganisms. The biofilters differ substantially on this point from the filters with adsorptive action such as activated charcoal filters and the like.

Solubility of the contents of the exhaust air in water is a prerequisite for biodegradability. Only dissolved materials are available for the microorganisms. For that, it is necessary that the air flow be as even as possible through an evenly moist layer of filter packing. A finely fibrous filter material with a large surface area is desirable so as to make possible the densest possible colonization by adapted microorganisms. That requires maintenance of a constant moisture content in the packing material of the biofilter. The moist filter material is not only an adsorption surface for the materials in the exhaust air, but also a culture surface for the microorganisms. This is also called the biofilm. The microorganisms take up the pollutants which transferred from the exhaust air to the water into their cells. However, the microorganism must also take up oxygen into the cell. Oxygen is consumed in degradation of the pollutant. The degradation process produces carbon dioxide (CO_2) and water (H_2O). The microorganisms multiply continuously, so

that as cells die off they are replaced by subsequent generations.

Thus the filter material must have enough water capacity to maintain the required moisture content. If the biofilm dries out, then there is no microbial degradation of the pollutants. On the other hand, flooding of the filter material is also harmful, because then not enough oxygen can diffuse from the gas into the water phase and to the microorganisms. If there is an oxygen deficiency, the filter action is reduced.

Flooding of the filter can be avoided in part by drains, but only to the extent allowed by the structure of the filter. On the other hand, drying of the filter cannot be avoided with existing fillings, at least in the vicinity of the surface.

Biofilters are generally made of packing material in a thickness of 1 – 1.5 meters. Surface areas can be from several square meters up to 30,000 or more square meters, depending on the input of the air to be cleaned. They are set up in the open air and so are completely exposed to weather. In strong sunlight, the surface dries rapidly and so substantially impairs the filter action.

The invention begins here.

The objective of the invention is to improve the surfaces of such biofilters so that drying is avoided as much as possible, and that the uptake of water is limited in heavy rain, without impairment of the filter action.

The objective is attained according to the invention by placing on the filter a mat that has an open-pore structure and also has a fine root system that does not penetrate deeply, and has a uniform flat lawn of growth at the surface.

Such cover mats have the advantage that the action of sunlight is kept away from the actual filter material. In addition, the cover mat stores moisture and, in heavy rain, prevents excessive water penetration down into the filter. Furthermore, the cover mat can have drains through it, through which the excessive water is led off.

The structure of the entire filter is shown in the drawings of examples.

Figure 1 shows the filter structure.

Figure 2 shows the degradation by microorganisms.

In Figure 1, the organic material **1** is piled up to a depth of 1 meter. Below this material is the exhaust air duct **2** through which the exhaust air to be cleaned is led under the filter material **1** and then flows through it. The exhaust air is led to the vicinity of the filter through feed line **3**. The cover mat **4** is on top of the biofilter. It consists of runway mats **[see Translator's note #1]** or plates that can be laid down easily and can be removed at any time. That also assures easy replacement of the cover mats.

A mat having a structure that meets all the requirements was developed to improve the capacity of open surface biofilters. It consists essentially of organic materials which can support growth of certain seeds. The seeds applied are specially cultured grass varieties with very fine root systems that extend no more than a few centimeters and form a fine loose root mat. At the same time, they provide an open-pore structure as a composite of the root mat and the finely fibrous organic materials, so that the flow through the filter is not impaired. Furthermore, the seeds are cultured so that they do not get very tall and nevertheless have a high density. These cover mats can vary in their thickness from a few centimeters up to 10–20 cm.

The properties of these cover mats include that they are nourished by the moisture in the exhaust air; that they bind a large amount of water during heavy rainfalls; and that, because of their thickness, they greatly reduce the effect of exposure to the sun when the sunlight is strong, thus providing for maintaining the required moisture content in the filter.

If the mat is harmed by wind-borne seeds from other plants in the course of the year, it can easily be removed and replaced by a net mat. Thus a continuous steady growth is maintained on the filter surface, requiring no further work.

Another advantage appears from the fact that the mat provides a buffer capacity against pH fluctuations in the root zone. A filter without green growth is strongly acidic in all depth zones, due to the acids formed on oxidation of ammonia; but the filter with green growth has only weak pH values, especially in the root area of the green growth. As most organisms have their pH optimum in the neutral range, the buffer action of the root-containing area is significant for the metabolic activity of the microbial population.

The pH describes the hydrogen ion capacity **[see Translator's note #2]** of an aqueous solution. Bacteria generally grow best at neutral to slightly alkaline pH. Fungi, on the other hand, prefer a slightly acidic H. A biofilter of organic materials is able to compensate for pH fluctuations by its buffer capacity, within certain limits.

Thus is also supported by the green growth. That also contributes to the fact that the temperature in the underlying filter rises but does not reach excessive values. The optimum temperature for most microorganisms is between 15 °C and 40 °C.

Figure 2 shows degradation of the pollutants. Oxidation favors cell multiplication and thus growth of the cell mass. Then application of the cover mat has the result that the cleaning effect for the exhaust air is improved and there is simultaneous protection against erosion.

Fungi and bacteria are carried up through the filter and typically escape into the surrounding air. These fungi and bacteria are held as much as possible in the cover mat, so that by their growth the counteract this loss of microorganisms. Thus the cover mat is

an additional biological safety net. Also, the improved moisture content in the biofilter prevents heavier fungal growth, as those thrive particularly well only in the drier parts.

Patent Claims

1. Biofilter for biological cleaning of exhaust air, comprising layered organic materials in which the substances contained in the gases flowing through are degraded by the metabolic activity of microorganisms,
characterized in that the entire surface of the filter is covered with a cover mat made up of organic substances, is made up of organic substances, has an open-pore structure, and has a fine root system that does not penetrate deeply so that green growth can be attained evenly across the surface of the filter.

2. Biofilter according to Claim 1, characterized in that the cover mat is made of organic substances such as coir, jute and the like, which are impregnated with short-growing seeds forming a green growth.

3. Biofilter according to Claims 1 and 2, characterized in that the cover mat is made in the form of a plate.

4. Biofilter according to Claims 1 and 2, characterized in that the cover mat is made as a runway mat.

5. Biofilter according to Claim 1 to 4, characterized in that the cover mat is replaceable.

6. Biofilter according to Claim 1, characterized in that the cover mat is made in the form of a plate or a runway mat, has a structure closed at all sides which holds organic substances impregnated with seeds, and that the seeds form green plants with fine root systems that do not penetrate deeply and produce only short stems and that the organic substances surrounding the green plants are simultaneously the nutrients for growth.

7. Biofilter according to Claim 1, characterized in that the cover mat as a biological safety net counteracts the loss of microorganisms, produced by fungi and bacteria.

With 1 page of drawings

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Figure 1

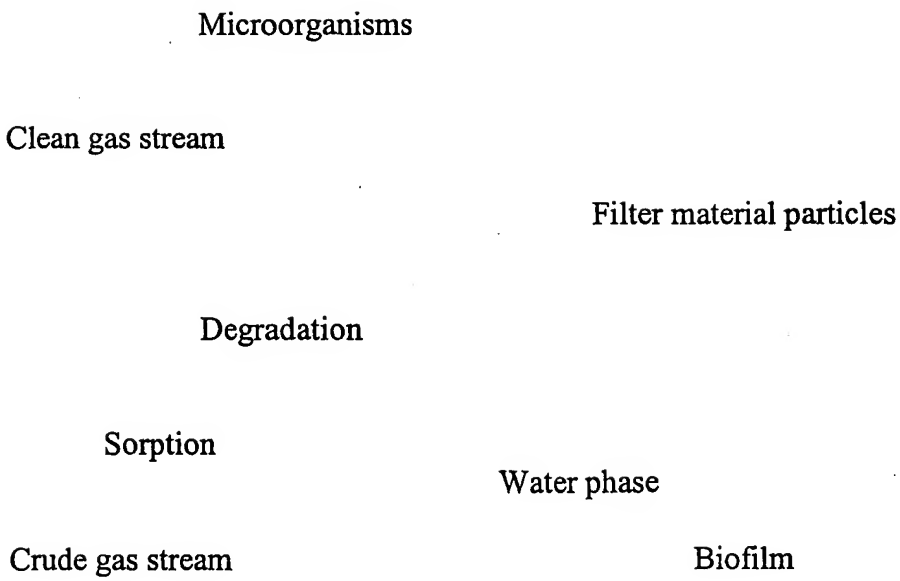

Figure 2

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Translator's notes:

1. German column 2, line 58: Rollenbahnen
   There are various possible meanings, but the term is translated here as 'runway mats', referring to the flat perforated steel sheets that were commonly used for fast landing strip preparation during World War II.

2. German column 3, line 34: "Der pH-Wert beschreibt die Wasserstoffionenkapazität . . ."
   " The pH describes the hydrogen ion capacity . . ."
   a. The "Wert" ("value" is normally omitted in English."
   b. The pH is normally considered to indicate the hydrogen ion **activity.**